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⑤④ **A surface-coated cemented carbide article or part.**

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⑤⑥ References cited :
EP-A- 0 074 759
EP-A- 0 083 043
AT-A- 631 772
DE-A- 3 039 775
DE-A- 3 234 943
GB-A- 1 425 633
GB-A- 2 006 727
JP-A-55 107 605
US-A- 4 237 184
Jap.laid open patent application No.89 805/78,
(JP-A-4512/77)english translation of claims 1 and 2

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Description

Background of the invention

1. Field of the invention

This invention relates to surface-coated cemented carbide articles and more particularly, it is concerned with surface-coated cemented carbide articles or parts, for example, for cutting tools having hard coating layers, capable of resisting severer cutting conditions.

2. Description of the prior art

It is well known in cutting tools that the temperature of a tool edge is 800°C or higher during cutting. As the temperature of an edge becomes higher, a cemented carbide such as WC-Co deforms by heat to lower the flank wear resistance. Various surface-coated cemented carbides having hard coating layers have thus been used so as to improve the cutting property, but the effects of these hard coating layers are not sufficient and the above described problem has not been solved. Thus, the life of such a tool is often shortened by deformation due to heat of the cemented carbide as a substrate.

When a cemented carbide is coated with a hard layer, the strength of an edge is lowered as compared with the cemented carbide as a substrate and thus the tool tends to be broken and can hardly exhibit high effectiveness for any of many kinds of workpieces such as of steel or cast iron.

The coating layers can be divided broadly into two categories: (1) single layers of TiC, TiCN or TiN and composite layers thereof, which will hereinafter be referred to as "Ti compound system" and (2) coating layers comprising an Al_2O_3 layer as the outermost layer, which will hereinafter be referred to as " Al_2O_3 system". Typical of the coating of Ti compound system are those described in Japanese Patent Publication No. 24982/1976 which discloses a film structure comprising an inner layer of TiC and an outer layer of TiN, or an inner layer of TiC, an intermediate layer of TiCN and an outer layer of TiN such that the nitrogen content is gradually increased from the inside to the outside, the film structure having both of an excellent rake surface wear resistance and flank wear resistance. In the coating layer structure of this kind, however, the substrate of a cemented carbide tends to deform by heat generated during cutting, for example, in the case of heavy cutting or high speed cutting and the effects by coating hard layers are not sufficiently exhibited in wear resistance.

In general, when the wear of a tool is increased to some extent, the cutting resistance is increased, thus resulting in rapid progress of wearing and breakage of the edge, so that the life of the tool be unstable. Lately, stabilization of the tool life has been required for the purpose of elimination or reduction of labor in cutting operation and there has been a tendency of exchanging a tool for another when the flank wear width reaches approximately 0.1 to 0.15 mm, although in the prior art, a tool was generally used until reaching a flank wear width of about 0.2 to 0.3 mm. The flank wear width of approximately 0.1 to 0.15 mm has called the initial flank wear width which will hereinafter be referred to as "initial wear" and of late, this initial wear resistance has been considered as an important factor to govern the tool life.

On the other hand, Al_2O_3 -coated cemented carbides, for example, as disclosed in Japanese Patent Publication No. 13201/1977, show an excellent wear resistance in high speed cutting because of the excellent heat resistance and nonreactivity with steels of Al_2O_3 , but have a problem of breakage resistance because of the brittleness of Al_2O_3 itself.

Summary of the invention

It is an object of the present invention to provide surface-coated cemented carbide articles or parts for cutting tools whereby the above described disadvantages of the prior art can be overcome.

It is another object of the present invention to provide a cemented carbide part having a coating excellent in heat shielding effect as well as initial wear resistance.

It is a further object of the present invention to provide a cutting tool having an excellent breakage resistance and long life.

These objects can be attained by a cemented carbide article having a hard coating layer on the surface thereof, in which the hard coating layer comprises an inner layer of TiC and an outer layer of TiC, and an intermediate layer, provided between the inner layer and outer layer, consisting of at least one layer which is either a single layer of TiN or a composite wherein a TiN layer is sandwiched between TiCN layers: the hard coating layer further having an outermost layer of Al_2O_3 with a thickness of 0.5 to 5 microns, and wherein the inner or outer layer of TiC has a thickness of 0.5 to 2.5 microns, the layer of TiN has a thickness of 0.5 to 2.5 microns

and each layer of TiCN if any has a thickness of 0.1 to 2.5 microns.

Brief description of the drawing

- 5 The accompanying drawings are to illustrate the principle and merits of the invention in greater detail.
 Fig. 1 is a typical view for showing a broken state of an insert after cutting: (a) top view and (b) front view; 1 rake face, 2 flank face, K_T depth of crater, V_S thermal deformation, V_B flank wear width, V_C nose wear, V_N flank notch wear.
 Fig. 2 is a cross sectional view of a workpiece to be cut used in a cutting test.

Detailed description of the invention

15 We, the inventors, have made various efforts to obtain a surface-coated cemented carbide article with the structure of a coating layer more excellent in heat shielding effect and initial wear resistance than Ti-compound coated cemented carbides.

In Ti compounds, the thermal conductivity is in the order of TiC, TiCN and TiN, i.e. TiC having a highest thermal conductivity, and the hardness is in the order of TiC, TiCN and TiN, i.e. TiC having a highest hardness. Table 1 shows the properties of TiC and TiN. TiCN has intermediate properties between them. The data of Table 1 are described in R. Funk "Coating of Cemented Carbide Cutting Tools with Alumina by Chemical Vapor Deposition" (J. Electrochem. Soc., Vol. 123, No. 2 (16)).

	TABLE 1		TiN	TiC
25	Microhardness (kg/mm ²)	20°C	1,950	3,200
	Thermal conductivity (Cal/cm · S · °C)	20°C	0.048	0.078
30		1,100°C	0.063	0.099

35 In order to reduce the heat transfer to a cemented carbide substrate during cutting, it is desirable to coat TiN with a lower thermal conductivity, but when using TiN only, the wear resistance is inferior because of the lower hardness than TiC. Thus, in order to exhibit effectively the heat shielding effect of TiN, we have noted that TiN has a lower thermal conductivity at a relatively lower temperature and have coated TiN as an inner layer at a relatively lower temperature of the coating layers during cutting, followed by coating TiC as an outer layer. It is assumed that the initial wear resistance of a tool is governed by the wear resistance of an outer layer within a range of about 3 microns in the coating layer and if TiC excellent in wear resistance is coated as an outer layer, an excellent initial wear resistance can be obtained, thus protecting TiN as a heat shielding layer.

40 When a surface-coated cemented carbide tool having the above described coating structure is made and subjected to estimation of the cutting property using a steel workpiece, deformation of the cemented carbide substrate by heat is reduced and the initial wear is also reduced as compared with the prior art coating structure consisting of an inner layer of TiC and an outer layer of TiN, but there arises a problem that the wear resistance is inferior thereto in cutting of castings. Thus, comparison of both the tools is carried out as to the bonding strength between the coating layer and cemented carbide substrate in order to know the cause of the above described problem and consequently, it is found that the use of TiC as an inner layer results in a higher bonding strength than the use of TiN as an inner layer.

50 That is, when a tool is prepared by coating a cemented carbide substrate with TiC as an innermost layer, with TiN as an intermediate layer and with TiC as an outermost layer and estimated, it is found that as compared with the Ti-compound coated cemented carbides of the prior art, the thermal deformation of the cemented carbide substrate is reduced, the initial wear resistance is increased, better results are also given in cutting of castings and the adaptability to workpieces to be cut is more enhanced.

55 Furthermore, the advantages or merits of the present invention can be more effectively given by allowing TiCN having intermediate properties to exist between the layers of TiC and TiN so as to increase the bonding strength between the coating layers, to moderate the crystal strain and to increase the strength of the coating itself.

In the surface-coated cemented carbide article of the present invention, the substrate or base member used

consists of cemented carbides which are sintered products containing one or more materials selected from carbides and carbonitrides of one or more metals selected from titanium, zirconium, hafnium, vanadium, columbium, tantalum, chromium, molybdenum and tungsten, cemented by one or more metals selected from the iron group, that is, iron, nickel and cobalt, in general, in a proportion of up to 30% by weight. Coating of a cemented carbide substrate with TiC, TiN, TiCN and Al_2O_3 is generally carried out by the so-called chemical vapor deposition method.

Generally, a cemented carbide article coated with a hard layer has the disadvantage, as well known in the art, that the edge strength is lower than that of the cemented carbide substrate and the tool tends to be broken.

We have made studies in order to overcome this disadvantage and consequently, have found that the breakage resistance of a tool can be made higher than Ti-compound coated cemented carbides of the prior art by the coating structure wherein each of the TiC layers and TiN layer have a film thickness of 0.5 to 2.5 μ according to the present invention. For example, when a tool having a Ti-compound coating structure of the prior art, in which the inner layer of TiC has a thickness of 5 μ and the outer layer of TiN has a thickness of 2.5 μ , is compared with another tool having a coating structure of the present invention, in which the inner layer and outer layer of TiC each has a thickness of 2.5 μ and the intermediate layer of TiN has a thickness of 2.5 μ , the tool of the present invention is markedly superior to that of the prior art with respect to the breakage resistance, although they have the same whole thickness of TiC and TiN. The reason therefor can be assumed as follows: In the tool of the present invention, TiC is coated separately in two layers, so that the grain growth is suppressed as compared with the case of coating a single layer of TiC with the same thickness as the total thickness of the two layers, and propagation of cracks is thus diffused through the fine grains, thus preventing the tool from breakage.

In this case, the effects are substantially the same in both the cases where the intermediate layer is of a single layer of TiN and a composite layer of TiN and TiCN. When TiCN is coated between TiC and TiN layers, the toughness is further improved. In this case, the breakage resistance can further be increased if the TiC and TiN layers each has a film thickness of 0.5 to 2.5 μ and the TiCN layer has a film thickness of 0.1 to 2.5 μ . If the thickness of the each layer exceeds 2.5 μ , the effect of making fine the crystal grains is decreased and the breakage resistance is lowered, while if the thickness of TiC and TiN are respectively less than 0.5 μ , there are little effects of shielding heat and improving the wear resistance and if the thickness of TiCN is less than 0.1 μ , there is little effect of improving the toughness.

As described above, the coating structure of the present invention consists in a basic structure of TiC/TiN/TiC and at least one of this multilayer is required. In a preferable embodiment, a more stable tool can be obtained by coating repeatedly a plurality of the multilayers.

The present invention also provides a surface-coated cemented carbide article or part having an excellent heat resistance in addition to the above described properties by further coating the coating layer having the above described basic structure with Al_2O_3 as an outermost layer. In this case, however, if the thickness of the Al_2O_3 film is less than 0.5 μ , the effect of this coating is little, while if more than 0.5 μ , the breakage resistance of a tool edge is remarkably lowered. Thus, the thickness should be 0.5 to 5.0 μ and a range of 0.5 to 3.0 μ is more preferable for holding the toughness.

In order to increase the bonding strength of the Al_2O_3 film, a bonding layer of TiBN, TiCBN, TiCO, TiNO or TiCNO with a thickness of 0.3 to 1.0 μ can be provided between the TiC layer and Al_2O_3 layer without reduction of the advantages of the present invention.

Furthermore, a TiN layer with a thickness of less than 2.0 μ can be coated for the purpose of coloring onto the outside of the Al_2O_3 layer without affecting the advantages of the present invention.

The following example given in order to illustrate the present invention in detail without limiting the same.

Example

A cemented carbide of ISO P 10 (commercial name) was coated with coating layers as shown in Tables 2 and 3 by the known vapor deposition method and then subjected to estimation of the cutting properties, thus obtaining results as shown in Tables 2 and 3. The method of estimating the cutting properties is shown in Table 4.

In comparison of Sample Nos. 4, 5 and 6 of the present invention with Sample No. 1 for comparison, it is apparent that the samples of the present invention show less quantities than the comparative sample as to the quantity of thermal deformation, flank wear width and breakage ratio, i.e. the former having more excellent cutting properties than the latter. In Sample Nos. 2, 3 and 4 for comparison, the film thickness of Al_2O_3 as the outermost layer only is changed and it is apparent from these results that the breakage ratio is increased with the increase of the thickness of Al_2O_3 , while the thermal deformation and flank wear width are increased with the decrease of the thickness of Al_2O_3 . Thus, it will clearly be understood that Sample No. 4 of the present invention

is more excellent from the standpoint of overall cutting properties.

In table 3, the total thickness of the coating layers is increased. It is apparent from these results that Sample Nos. 8 and 9 show less quantities than Sample No. 7 for comparison as to the quantity of thermal deformation and flank wear width, i.e., showing more excellent cutting properties, but Sample No. 8 is not so different from Sample 7 as to the breakage ratio. On the other hand, Sample No. 9 is more excellent than the comparative sample in all aspects. Therefore, when the film thickness of the each layer of TiC, TiCN or TiN is less than 2.5 μ , a more excellent breakage resistance can also be obtained in the case of using Al_2O_3 coating layers in an analogous manner to the case of using Ti compounds coating layers.

TABLE 2

Sample No.	Coating layer structure (μ)						Total thickness	Cutting properties*			
	Inner layer			Outer layer				(I)	(III)	(IV)	
Comparison											
1	TiC	TiN	Al ₂ O ₃				8.5	0.144	0.275	59	
	5.0	2.5	1.0								
2	TiC	TiN	TiC	Al ₂ O ₃			14.5	0.052	0.172	95	
	2.5	2.5	2.5	7.0							
3	TiC	TiN	TiC	Al ₂ O ₃			7.8	0.152	0.312	50	
	2.5	2.5	2.5	0.3							
Our invention											
4	TiC	TiN	TiC	Al ₂ O ₃			8.5	0.093	0.220	34	
	2.5	2.5	2.5	1.0							
5	TiC	TiCN	TiN	TiCN	TiC	Al ₂ O ₃	8.5	0.095	0.203	21	
	2.0	1.0	1.5	1.0	2.0	1.0					
6	TiC	TiCN	TiN	TiCN	TiC	TiBN	Al ₂ O ₃	9.5	0.094	0.201	23
	2.0	1.0	1.5	1.0	2.0	0.5	1.0	0.5			

Note : * (I) Quantity of thermal deformation (mm).

(III) Flank wear width (mm)

(IV) Breakage ratio (%)

TABLE 3

Sample No.	Coating layer structure (μ)						Total thickness	Cutting properties*			
	Inner layer			Outer layer				(I)	(III)	(IV)	
Comparison											
45	7	TiC	TiN	Al ₂ O ₃				13.5	0.072	0.163	87
		6.5	6.0	1.0							
50	8	TiC	TiN	TiC	Al ₂ O ₃			13.5	0.063	0.136	83
		3.5	6.0	3.0	1.0						
	our invention										
	9	TiC	TiCN	TiN	TiCN	TiC	Al ₂ O ₃	13.5	0.061	0.134	62
		2.5	2.5	2.5	2.5	2.5	1.0				

Note: *(I), (III) and (IV) same as in Table 2

TABLE 4

	Workpiece (hardness)	Cutting speed (m/min)	Feed (mm/rev)	Depth of cut (mm)	Cutting time (min)	Tool form No.
5 Quantity of thermal deformation*	SK 5 (H _v 250)	150	0.74	1.5	5	SNMG 432
10 Flank wear width	SCM 435 (H _v 250)	170	0.37	2.0	60	SNMG 432
15 Breakage ratio**	SCM 435 with groove	100	0.17-0.27	1.5	0.5	SNMG 432

Note : * Quantity of thermal deformation is represented by Vs in Fig. 1 showing a broken state of a cutting insert after cutting.

** Breakage ratio is a relative value in a 10 edges cutting test of a grooved workpiece having a cross section as shown in Fig. 2.

Claims

1. A surface-coated cemented carbide article having a hard coating layer on the surface thereof, in which the hard coating layer comprises an inner layer of TiC and an outer layer of TiC, and an intermediate layer, provided between the inner layer and outer layer, consisting of at least one layer which is either a single layer of TiN or a composite wherein a TiN layer is sandwiched between TiCN layers, the hard coating layer further having an outermost layer of Al₂O₃ with a thickness of 0.5 to 5 microns; and wherein the inner or outer layer of TiC has a thickness of 0.5 to 2.5 microns, the layer of TiN has a thickness of 0.5 to 2.5 microns and each layer of TiCN if any has a thickness of 0.1 to 2.5 microns.

2. A surface-coated cemented carbide article according to Claim 1, wherein the outermost layer of Al₂O₃ is coated through a bonding layer coated on the outer layer of TiC, the bonding layer consisting of at least one material selected from the group consisting of TiBN, TiCBN, TiCO, TiNO and TiCNO and having a thickness of 0.3 to 1 micron.

3. A surface-coated cemented carbide article according to Claim 1, wherein the layer of TiC, the intermediate layer and the layer of TiC are repeated.

Revendications

1. Article en carbure cimenté à surface revêtue ayant une couche de revêtement dure sur sa surface, dans lequel la couche de revêtement dure comprend une couche interne de TiC et une couche externe de TiC et une couche intermédiaire prévue entre la couche interne et la couche externe, consistant en au moins une couche qui est soit une couche unique de TiN ou une couche composite dans laquelle une couche de TiN est insérée entre des couches de TiCN, la couche de revêtement dure ayant de plus une couche extérieure en Al₂O₃ d'une épaisseur de 0,5 à 5 microns, et dans lequel la couche interne ou externe de TiC a une épaisseur de 0,5 à 2,5 microns, la couche de TiN a une épaisseur de 0,5 à 2,5 microns et chaque couche de TiCN si elle existe a une épaisseur de 0,1 à 2,5 microns.

2. Article en carbure cimenté à surface revêtue selon la revendication 1, dans lequel la couche la plus externe de Al₂O₃ est appliquée par l'intermédiaire d'une couche de liaison appliquée sur la couche externe de TiC, la couche de liaison consistant en au moins un matériau choisi dans le groupe formé par TiBN, TiCBN,

TiCO, TiNO et TiCNO et ayant une épaisseur de 0,3 à 1 micron.

3. Article en carbure cémenté à surface revêtue selon la revendication 1, dans lequel la couche de TiC, la couche intermédiaire et la couche de TiC sont répétées.

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Patentansprüche

1. Oberflächenbeschichtetes zementiertes Carbiderzeugnis mit einer harten Beschichtung auf der Oberfläche, bei dem die harte Beschichtung eine Innenschicht aus TiC und eine Außenschicht aus TiC sowie eine Zwischenschicht umfaßt, die zwischen der Innen- und der Außenschicht angeordnet ist und aus wenigstens einer Schicht besteht, die entweder eine Einzelschicht aus TiN oder einen Verbundkörper darstellt, wobei eine TiN-Schicht zwischen TiCN-Schichten angeordnet ist, und die harte Beschichtung außerdem noch eine Außenschicht aus Al_2O_3 mit einer Dicke von 0,5 bis 5 μm aufweist, und die Innen- bzw. Außenschicht aus TiC eine Dicke von 0,5 bis 2,5 μm , die TiN-Schicht eine Dicke von 0,5 bis 2,5 μm und jede TiCN-Schicht, sofern vorhanden, eine Dicke von 0,1 bis 2,5 μm aufweist.

2. Oberflächenbeschichtetes zementiertes Carbiderzeugnis nach Anspruch 1, wobei die Außenschicht aus Al_2O_3 mittels einer Bindemittelschicht auf die Außenschicht aus TiC aufgebracht ist und die Verbindungsschicht wenigstens aus einem Stoff, ausgewählt aus der Gruppe, bestehend aus TiBN, TiCBN, TiCO, TiNO und TiCNO, besteht und eine Dicke von 0,3 bis 1 μm aufweist.

3. Oberflächenbeschichtetes zementiertes Carbiderzeugnis nach Anspruch 1, wobei die TiC-Schicht, die Zwischenschicht und die TiC-Schicht sich wiederholen.

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FIG. 1

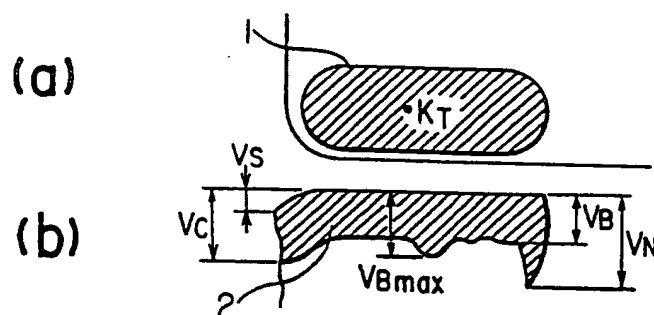


FIG. 2

